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Morioka et al.

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(54) **ULTRASONIC INSPECTION DEVICE AND METHOD OF ULTRASONIC INSPECTION**

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(58) **Field of Classification Search**
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(57) **ABSTRACT**

An ultrasonic inspection device includes: a vibration generating section that irradiates laser beam onto a first member to generate ultrasonic vibration; a detecting section that detects the ultrasonic vibration propagated from the first to a second members via a welded portion; and an analyzing section that analyzes the propagated ultrasonic vibration detected by the detecting section. The analyzing section obtains at least one of frequency and wavelength of the ultrasonic vibration detected by the detecting section upon when a displacement in the second member in a thickness direction becomes maximum. The analyzing section obtains a cross sectional dimension of the welded portion from a correlated relationship of the cross sectional dimension of the welded portion obtained in advance at a position on a surface of the second member on the first member side and

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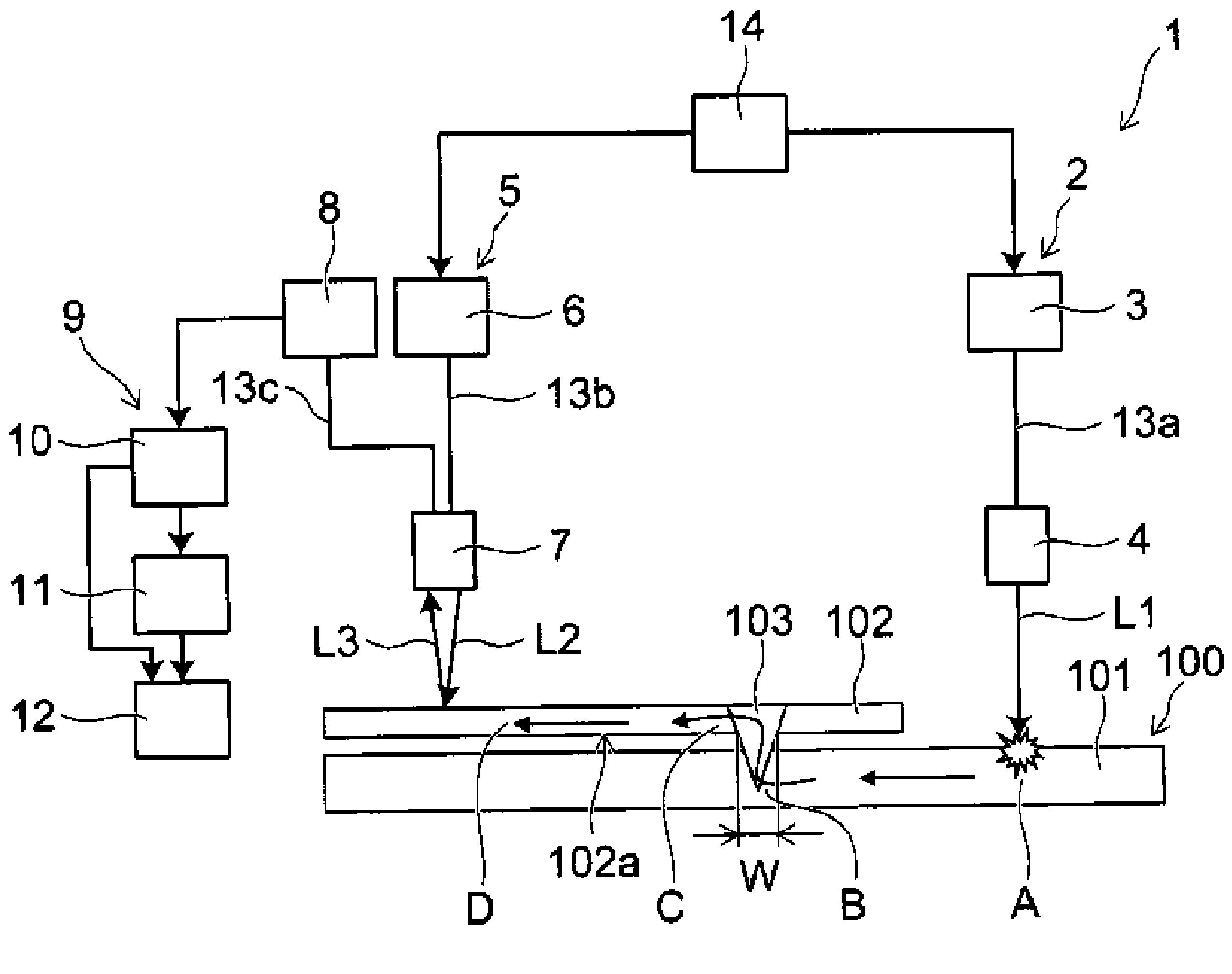

the at least one of the frequency and wavelength of the ultrasonic vibration.

20 Claims, 2 Drawing Sheets

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G01N 29/24 (2006.01)
G01N 29/46 (2006.01)

(58) **Field of Classification Search**
USPC 73/643, 622, 624, 648, 598, 588; 356/511
See application file for complete search history.

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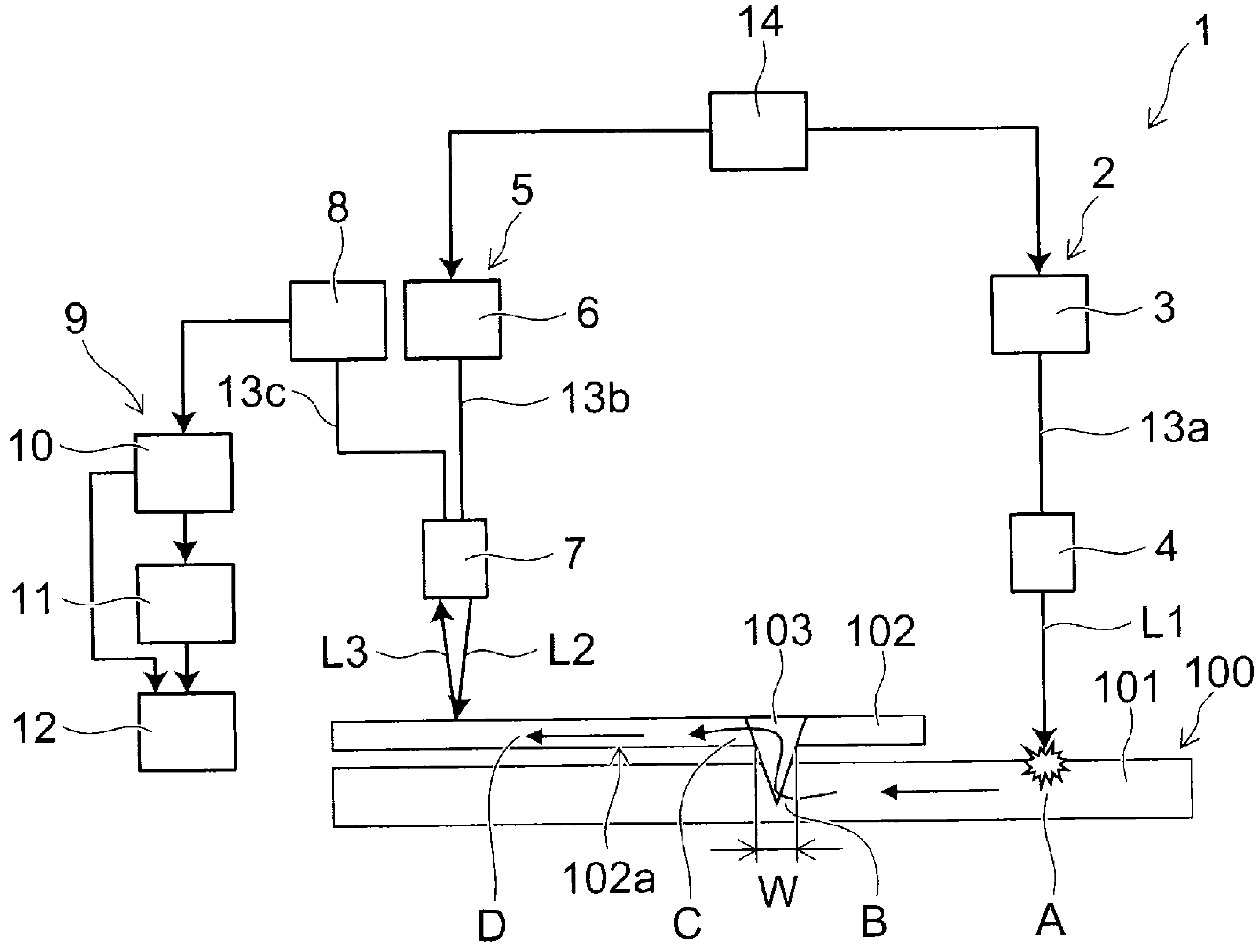
14
1
5
2
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11
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W
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FIG. 1

FIG. 2A

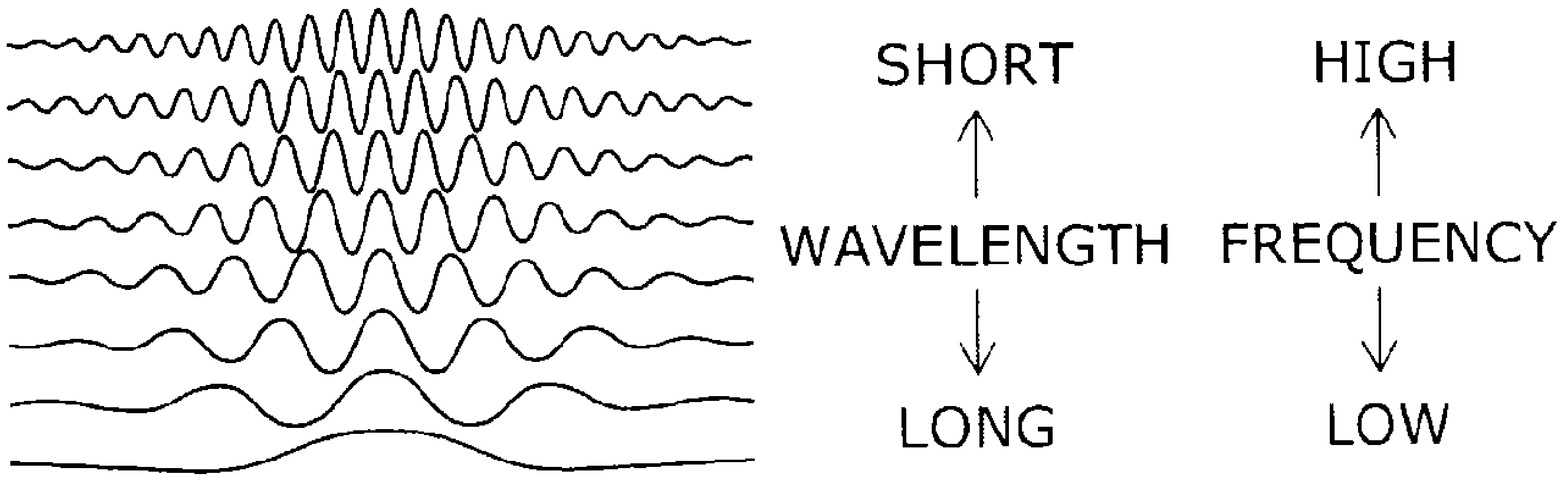


FIG. 2B

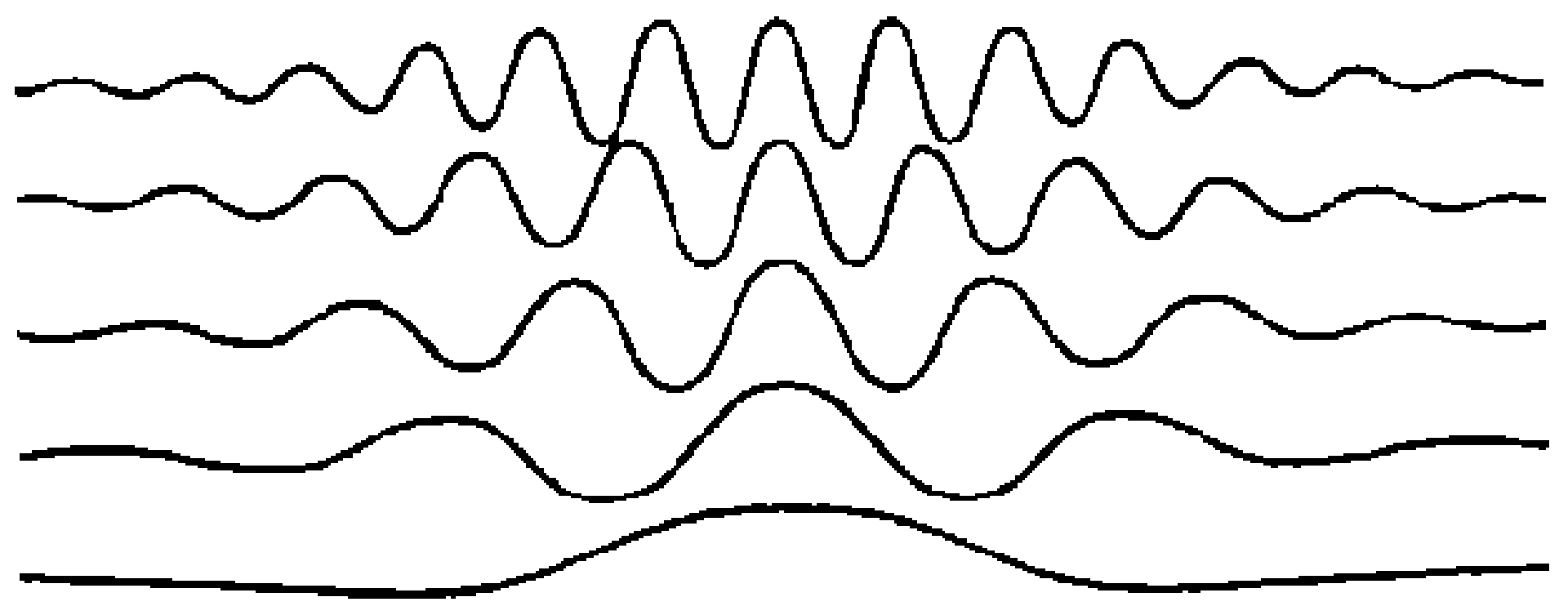


FIG. 2C

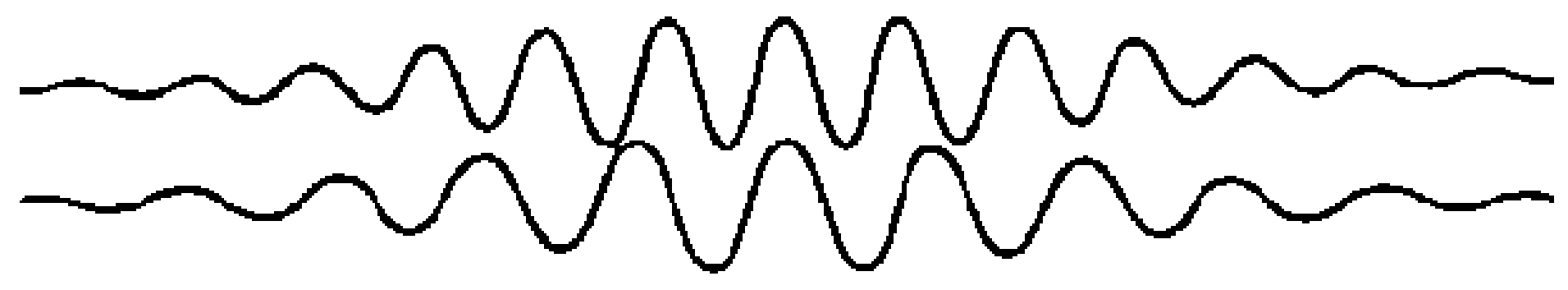
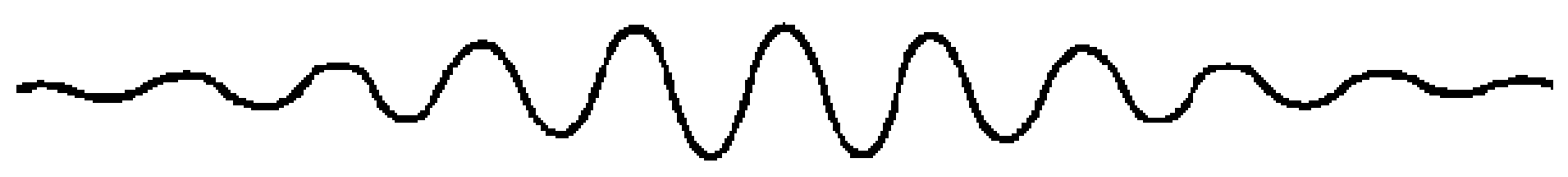


FIG. 2D



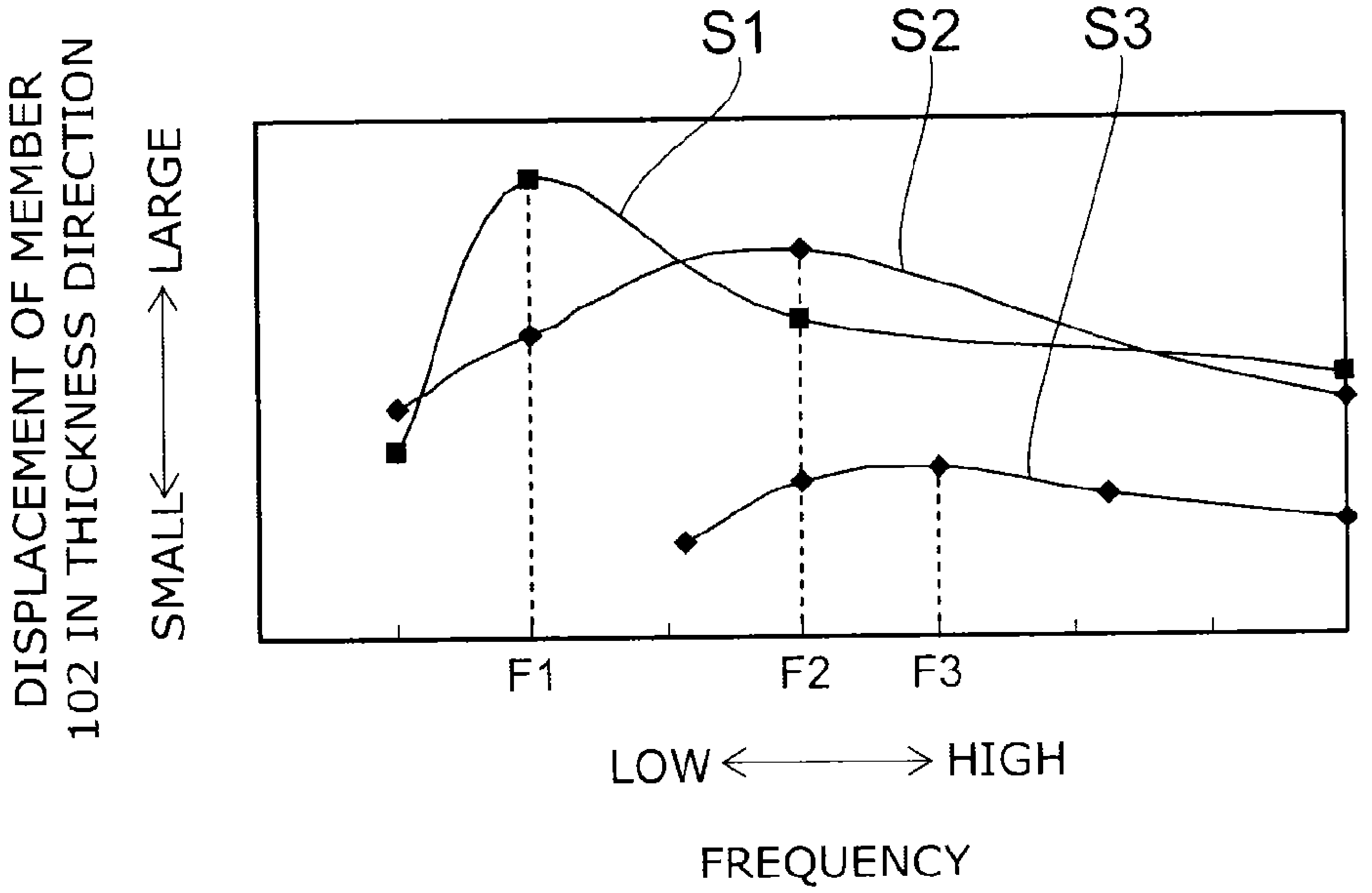


FIG. 3

ULTRASONIC INSPECTION DEVICE AND METHOD OF ULTRASONIC INSPECTION

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is based upon and claims the benefit of priority from Japanese Patent Application No. 2013-061142, filed on Mar. 22, 2013; the entire contents of which are incorporated herein by reference.

FIELD

Embodiments described herein relate generally to a ultrasonic inspection device and a method of ultrasonic inspection.

BACKGROUND

There is a method of ultrasonic inspection that inspects an internal condition of an inspection target by generating ultrasonic vibration in the inspection target by irradiating laser beam on the inspection target, and analyzing the ultrasonic vibration that propagates in the inspection target.

Further, a technique is being proposed that predeterminedly calculates a frequency by which a base metal resonates, scans a position where ultrasonic vibration is to be generated and a position where the ultrasonic vibration is to be detected, calculates a dimension of a region where the base metal resonates at a lower frequency than its resonating frequency from the scanned positions, and sets the calculated dimension of the region as a dimension of a welded portion.

However, there are risks by which the method of ultrasonic inspection becomes burdensome, and an ultrasonic inspection device becomes complicated.

Due to this, a development of a technique that can easily detect the dimension of the welded portion has long been desired.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic view for illustrating an ultrasonic inspection device of an embodiment;

FIGS. **2**A to **2**D are schematic views for illustrating how ultrasonic vibration is propagated; and

FIG. **3** is a graph for illustrating an example of a frequency analysis of the ultrasonic vibration that reached a position where a laser beam is irradiated.

DETAILED DESCRIPTION

In general, according to one embodiment, an ultrasonic inspection device includes: a vibration generating section that irradiates laser beam onto a first member to generate ultrasonic vibration; a detecting section that detects the ultrasonic vibration propagated from the first member to a second member via a welded portion; and an analyzing section that analyzes the propagated ultrasonic vibration detected by the detecting section. The analyzing section obtains at least one of frequency and wavelength of the ultrasonic vibration detected by the detecting section upon when a displacement in the second member in a thickness direction becomes maximum. The analyzing section obtains a cross sectional dimension of the welded portion from a correlated relationship of the cross sectional dimension of the welded portion obtained in advance at a position on a surface of the second member on the first member side and the at least one of the frequency and wavelength of the ultrasonic vibration.

In general, according to another embodiment, a method of ultrasonic inspection includes: generating ultrasonic vibration by irradiating laser beam onto a first member; detecting the ultrasonic vibration propagated from the first member to a second member via a welded portion; and obtaining at least one of frequency and wavelength of the ultrasonic vibration detected upon when a displacement in the second member in a thickness direction becomes maximum, and obtaining a cross sectional dimension of the welded portion from a correlated relationship of the cross sectional dimension of the welded portion obtained in advance at a position on a surface of the second member on the first member side and the at least one of the frequency and wavelength of the ultrasonic vibration.

Hereinbelow, an embodiment will be illustrated with reference to the drawings. Notably, in the respective drawings, a same reference sign is given to similar constituent elements, and a detailed description thereof will suitably be omitted.

FIG. **1** is a schematic view for illustrating an ultrasonic inspection device **1** of the embodiment.

Firstly, an inspection target **100** will be described.

As shown in FIG. **1**, the inspection target **100** is welded at a portion where a member **101** (corresponding to an example of a first member) and a member **102** (corresponding to an example of a second member) are overlapped. For example, the member **101** and the member **102** are plug welded or slot welded.

The portion that had been welded is shown as a welded portion **103**.

Further, a cross sectional dimension of the welded portion **103** at a position of a surface (a surface **102***a* illustrated in FIG. **1**) of the member that is on a detecting side of ultrasonic vibration (the member **102** illustrated in FIG. **1**) on a side of the member that is on a generating side of the ultrasonic vibration (the member **101** illustrated in FIG. **1**) is termed W (hereinbelow simply be referred to as the cross sectional dimension W of the welded portion **103**).

Notably, in FIG. **1**, although a gap is provided between the member **101** and the member **102**, the member **101** and the member **102** may be in contact.

No limitation is made to materials of the member **101** and the member **102**. The materials of the member **101** and the member **102** may for example be metal, resin, and the like.

Here, there is a case where whether the welded portion **103** has suitable strength or not is to be inspected. In such a case, a member **102** side within the welded portion **103** where a plug or a slot is provided can be observed of its welded condition from outside.

However, a portion within the welded portion **103** formed between the member **101** and the member **102** cannot be observed of its welded condition from outside.

Further, a cross sectional dimension W of the welded portion **103** that cannot be observed from outside imposes a great influence on an aptitude of the welding strength.

Due to this, if the cross sectional dimension W of the welded portion **103** that cannot be observed from outside can be detected, the determination on the aptitude of the welding strength can be performed.

As will be described later, the ultrasonic inspection device **1** of the embodiment can easily detect the cross sectional dimension W of the welded portion **103**. Further, the aptitude of the welding strength can be determined based on the detected cross sectional dimension W of the welded portion **103** and a predetermined threshold.

Next, returning to FIG. **1**, the ultrasonic inspection device **1** will be illustrated.

The ultrasonic inspection device **1** is provided with a vibration generating section **2**, a detecting section **5**, an analyzing section **9**, and a control section **14**.

The vibration generating section **2** irradiates laser beam L**1** to the member **101** to generate ultrasonic vibration in the member **101**.

The vibration generating section **2** is provided with a laser beam source **3** (corresponding to an example of a first laser beam source) and an irradiation head **4**.

The laser beam source **3** is configured capable of emitting the laser beam L**1** that is of high energy and time modulated. The laser beam source **3** may for example be a pulse laser beam source. For the laser beam source **3**, for example, lasers that are capable of pulse oscillation such as a YAG laser, a CO_2 laser, a titanium sapphire laser, and an excimer laser may be used.

However, the laser beam source **3** is not limited to the illustrated examples, and any may be adapted so long as the ultrasonic vibration can be generated in the inspection target **100**.

The irradiation head **4** is connected to the laser beam source **3** via an optical fiber **13***a*. The irradiation head **4** irradiates the laser beam L**1** emitted from the laser beam source **3** onto a surface of the member **101**. The irradiation head **4** can be configured by including an optical element (for example, a lens and the like) that is not shown for concentrating the laser beam L**1**.

Notably, although a case in which the irradiation head **4** and the laser beam source **3** are connected via the optical fiber **13***a* is illustrated, no limitation is made hereto. The irradiation head **4** and the laser beam source **3** only need to be optically connected.

The detecting section **5** detects the ultrasonic vibration propagated in the member **102** welded with the member **101** at the portion where it overlaps with the member **101**. That is, the detecting section **5** detects the ultrasonic vibration that is generated by the vibration generating section **2** and propagated in the member **102** from the member **101** via the welded portion **103**.

Further, the detecting section **5** converts the detected ultrasonic vibration into an electric signal.

The detecting section **5** may for example be a laser interferometer.

The detecting section **5** is provided with a laser beam source **6** (corresponding to an example of a second laser beam source), a head **7**, and a converting section **8**.

As the laser beam source **6**, a semiconductor laser may for example be used.

The head **7** is connected to the laser beam source **6** via an optical fiber **13***b*. Further, the head **7** is connected to the converting section **8** via an optical fiber **13***c*. Notably, connections are not limited to those by the optical fibers **13***b*, **13***c*, and only need to be optically connected.

The head **7** irradiates laser beam L**2** emitted from the laser beam source **6** onto a surface of the member **102**. Further, the head **7** receives reflected light L**3** from the surface of the member **102**. The head **7** can be configured by including an optical element (for example, a lens and the like) that is not shown for concentrating the laser beam L**2**, L**3**.

An optical path length of the reflected light L**3** changes due to a change in a position in the surface of the member **102** (displacement of the member **102** in a thickness direction). Due to this, interfering light can be generated by causing the laser beam L**2** (reference light) that was emitted from the laser beam source **6** and reflected at a reflecting surface (reference surface) in the head **7** and the reflected light L**3** from the surface of the member **102** be interfered in the head **7**.

An intensity of the interfering light changes depending on a distance from the reflecting surface in the head **7** to the surface of the member **102**. Due to this, an amount of displacement of the member **102** in the thickness direction can be detected by the change in the intensity of the interfering light.

Further, the converting section **8** detects the ultrasonic vibration propagated in the member **102** by detecting the change in the intensity of the interfering light relative to elapsed time (displacement of the member **102** in the thickness direction relative to elapsed time).

Further, the converting section **8** converts the detected ultrasonic vibration into the electric signal. The converting section **8** can for example be configured by including a solid-state image sensing device such as CCDs (Charge Coupled Devices).

Notably, although an example in which the detecting section **5** is the laser interferometer has been illustrated, no limitation is made hereto. Any is applicable so long as the ultrasonic vibration propagated in the member **102** can be detected. For example, the detecting section **5** may be configured of a piezoelectric device.

However, an application range of the inspection target can be broadened if the detecting section **5** is configured capable of noncontact detection, such as with the laser interferometer.

The analyzing section **9** analyzes the ultrasonic vibration detected by the detecting section **5**.

For example, the analyzing section **9** obtains the cross sectional dimension W of the welded portion **103** based on the ultrasonic vibration detected by the detecting section **5**. Yet further, the analyzing section **9** determines the aptitude of the welding strength based on the calculated cross sectional dimension W of the welded portion **103**.

The analyzing section **9** is provided with a calculating section **10**, a determining section **11**, and a displaying section **12**.

The calculating section **10** calculates the cross sectional dimension W of the welded portion **103** based on the ultrasonic vibration detected by the detecting section **5**.

The calculating section **10** calculates the cross sectional dimension W of the welded portion **103** for example by conducting a frequency analysis of the ultrasonic vibration that has reached the position where the laser beam L**2** is irradiated. The frequency analysis of the ultrasonic vibration may for example be performed by a fast Fourier transformation (FFT).

For example, the calculating section **10** provided in the analyzing section **9** obtains at least one of the frequency and a wavelength of the ultrasonic vibration detected by the detecting section **5** upon when the displacement of the member **102** in the thickness direction becomes maximum. Then, the cross sectional dimension W of the welded portion **103** is obtained from a correlated relationship of a cross sectional dimension W of a welded portion as predeterminedly defined and at least one of the frequency and the wavelength of the ultrasonic vibration.

Notably, a method for obtaining the cross sectional dimension W of the welded portion **103** will be described later in detail.

The determining section **11** determines the aptitude of the welding strength based on the obtained cross sectional dimension W of the welded portion **103**. For example, in a case where the obtained cross sectional dimension W of the welded portion **103** is longer than a predetermined threshold, it can be determined that the welding strength is appropriate. Contrary to this, in a case where the obtained cross sectional dimension W of the welded portion **103** is shorter than the predetermined threshold, it can be determined that the welding strength is inappropriate. Notably, the threshold can be decided by experimenting and conducting simulations on the relationship of the cross sectional dimension W of the welded portion **103** and the welding strength.

The displaying section **12** displays the cross sectional dimension W of the welded portion **103** obtained by the calculating section **10** and the determination result of the welding strength by the determining section **11**. The displaying section **12** may for example be a liquid crystal display device.

The control section **14** controls the laser beam source **3** and the laser beam source **6**. The control section **14** controls for example the emission of the laser beam L**1** from the laser beam source **3**, stoppage of the emission of the laser beam L**1** and the like. The control section **14** may for example controls the emission of the laser beam L**2** from the laser beam source **6**, and stoppage of the emission of the laser beam L**2**.

Next, a method of ultrasonic inspection according to the embodiment will be illustrated together with workings of the ultrasonic inspection device **1**.

Firstly, the laser beam L**1** is caused to be emitted from the laser beam source **3** by the control section **14**. The laser beam L**1** emitted from the laser beam source **3** enters the irradiation head **4** via the optical fiber **13***a*. The laser beam L**1** that entered the irradiation head **4** is irradiated onto the surface of the member **101**. When the laser beam L**1** is irradiated onto the surface of the member **101**, a thermal strain and the like is generated at the surface of the member **101**, and high frequency elastic waves (ultrasonic waves) are generated in the member **101**. That is, the ultrasonic vibration is generated. The generated ultrasonic vibration propagates in the member **101**, and propagates to the member **102** via the welded portion **103**.

FIGS. **2**A to **2**D are schematic views for illustrating how the ultrasonic vibration is propagated.

FIG. **2**A is a schematic view for illustrating the ultrasonic vibration at an A part in FIG. **1**.

FIG. **2**B is a schematic view for illustrating the ultrasonic vibration at a B part in FIG. **1**.

FIG. **2**C is a schematic view for illustrating the ultrasonic vibration at a C part in FIG. **1**.

FIG. **2**D is a schematic view for illustrating the ultrasonic vibration at a D part in FIG. **1**.

As shown in FIG. **2**A, at a position where the laser beam L**1** is irradiated in the member **101** (A part in FIG. **1**), the ultrasonic vibration including various wavelengths (frequencies) is generated.

Next, the ultrasonic vibration generated at the position where the laser beam L**1** is irradiated in the member **101** propagates in the member **101**. At this occasion, the ultrasonic vibration having a short wavelength (having a high frequency) has a property of being difficult to propagate.

Due to this, as shown in FIG. **2**B, only the ultrasonic vibration having a relatively long wavelength (having a relatively low frequency) reaches the position in the vicinity of the welded portion **103** (B part in FIG. **1**) in the member **101**.

Further, in the occasion where the ultrasonic vibration reaches the member **102** by passing through the welded portion **103**, the ultrasonic vibration having a long wavelength (having a low frequency) has a property of being difficult to propagate through the welded portion **103**.

Due to this, as shown in FIG. **2**C, among the ultrasonic vibration that reached the position in the vicinity of the welded portion **103** in the member **101**, only the ultrasonic vibration having a short wavelength (having a high frequency) reaches the position in the vicinity of the welded portion **103** (C part in FIG. **1**) in the member **102**.

Here, according to the knowledge achieved by the inventors, it has been found that the wavelength (frequency) of the ultrasonic vibration that can pass through the welded portion **103** changes if the cross sectional dimension W of the welded portion **103** is changed. That is, it has been found that, as the cross sectional dimension W of the welded portion **103** becomes shorter, the wavelength (frequency) of the ultrasonic vibration that can pass through the welded portion **103** becomes shorter (higher).

The ultrasonic vibration that reached the position in the vicinity of the welded portion **103** in the member **102** propagates in the member **102**. At this occasion, the ultrasonic vibration having the short wavelength (having the high frequency) has the property of being difficult to propagate.

Due to this, as shown in FIG. **2**D, among the ultrasonic vibration that passed through of the welded portion **103**, only the ultrasonic vibration having the long wavelength (having the low frequency) reaches the position where the laser beam L**2** is irradiated (D part in FIG. **1**) in the member **102**.

That is, as described above, when the cross sectional dimension W of the welded portion **103** changes, the wavelength and the frequency of the ultrasonic vibration reaching the position where the laser beam L**2** is irradiated changes.

Due to this, the cross sectional dimension W of the welded portion **103** can be obtained by analyzing the wavelength and frequency of the ultrasonic vibration that reached the position where the laser beam L**2** is irradiated. Further, the aptitude of the welding strength can be determined based on the obtained cross sectional dimension W of the welded portion **103**.

FIG. **3** is a graph for illustrating an example of a frequency analysis of the ultrasonic vibration that reached the position where the laser beam L**2** is irradiated.

FIG. **3** conducted the frequency analysis on the ultrasonic vibration that reached the position where the laser beam L**2** is irradiated by using a fast Fourier transform.

S**1** in FIG. **3** is a case where the cross sectional dimension W of the welded portion **103** is 1 mm, S**2** is a case where the cross sectional dimension W of the welded portion **103** is 0.5 mm, and S**3** is a case where the cross sectional dimension W of the welded portion **103** is 0.1 mm.

As described above, the frequency of the ultrasonic vibration that can pass through the welded portion **103** becomes higher as the cross sectional dimension W of the welded portion **103** becomes shorter.

Due to this, as shown in FIG. **3**, a frequency property changes according to the cross sectional dimension W of the welded portion **103**. Further, it can be understood that when the cross sectional dimension W of the welded portion **103** changes, the frequency by which the displacement of the member **102** in the thickness direction becomes maximum changes. For example, in the case where the cross sectional dimension W of the welded portion **103** is 1 mm, the displacement of the member **102** in the thickness direction becomes maximum at a frequency F**1**. In the case where the cross sectional dimension W of the welded portion **103** is 0.5 mm, the displacement of the member **102** in the thickness direction becomes maximum at a frequency F**2**. In the case where the cross sectional dimension W of the welded portion **103** is 0.1 mm, the displacement of the member **102** in the thickness direction becomes maximum at a frequency F**3**.

That is, if a relationship of the cross sectional dimension W of the welded portion **103** and the frequency by which the displacement of the member **102** in the thickness direction becomes maximum is obtained in advance by experiments and simulations, the dimension of the cross sectional dimension W of the welded portion **103** can be obtained by detecting the frequency by which the displacement of the member **102** in the thickness direction becomes maximum. For example, if the displacement of the member **102** in the thickness direction becomes maximum at the frequency F**1**, it can be understood that the cross sectional dimension W of the welded portion **103** is 1 mm. For example, if the displacement of the member **102** in the thickness direction becomes maximum at the frequency F**2**, it can be understood that the cross sectional dimension W of the welded portion **103** is 0.5 mm. For example, if the displacement of the member **102** in the thickness direction becomes maximum at the frequency F**3**, it can be understood that the cross sectional dimension W of the welded portion **103** is 0.1 mm.

Further, the aptitude of the welding strength can be determined based on the cross sectional dimension W of the welded portion **103** obtained as above. For example, in a case where the obtained cross sectional dimension W of the welded portion **103** is longer than a predetermined threshold, it can be determined that the welding strength is appropriate. Contrary to this, in a case where the obtained cross sectional dimension W of the welded portion **103** is shorter than the predetermined threshold, it can be determined that the welding strength is inappropriate. The threshold can be decided by conducting experiments and simulations on the relationship of the cross sectional dimension W of the welded portion **103** and the welding strength.

Notably, by utilizing the fact that the displacement in the thickness direction becomes small when the cross sectional dimension W of the welded portion **103** becomes small, the appropriateness can be determined in a case there the displacement in the thickness direction exceeds the predetermined threshold at a peak frequency.

Notably, the above are cases of obtaining the cross sectional dimension W of the welded portion **103** based on the frequency, and determining the aptitude of the welding strength, however, for example, the cross sectional dimension W of the welded portion **103** can be obtained and the aptitude of the welding strength can be determined based on the wavelength.

As illustrated above, the method of ultrasonic inspection of the embodiment includes a process of causing the ultrasonic vibration to occur by irradiating laser beam onto the member **101**, a process of detecting the ultrasonic vibration propagated to the member **102** welded to the member **101** at the portion being overlapped with the member **101**, and a process of obtaining at least one of the frequency and wavelength of the ultrasonic vibration detected upon when the displacement of the member **102** in the thickness direction, and obtaining the cross sectional dimension W of the welded portion **103** from a correlated relationship of the predeterminedly obtained cross sectional dimension W of the welded portion **103** and at least one of the frequency and wavelength of the ultrasonic vibration.

In this case, the ultrasonic vibration caused to occur by irradiating the laser beam onto the member **101** and propagated to the member **102** from the member **101** via the welded portion **103** is detected in the process of detecting the ultrasonic vibration propagated in the member **102**.

Further, a process of determining the aptitude of the welding strength based on the obtained cross sectional dimension W of the welded portion **103** and the predeterminedly obtained threshold may further be provided.

Further, according to the findings of the inventors, in assuming that the frequency of the ultrasonic vibration upon when the displacement of the member **102** in the thickness direction becomes maximum is F, the cross sectional dimension of the welded portion **103** is W, and a speed of the propagating ultrasonic vibration is V, it has been found that $V/5W \leq F \leq V/W$ is satisfied.

Notably, in the above, the case in which the member **101** and the member **102** are either plug welded or slot welded has been illustrated, it can be adapted to a case in which the member **101** and the member **102** are spot welded.

According to the ultrasonic inspection device **1** and the method of ultrasonic inspection of the embodiment, the cross sectional dimension W of the welded portion **103** can be obtained by irradiating the laser beam L**1** onto the member **101**, and analyzing the frequency and the wavelength of the ultrasonic vibration propagated in the member **102** via the welded portion **103**. Further, the determination on whether the welding strength is appropriate or not can be made based on the obtained cross sectional dimension W of the welded portion **103**.

That is, the cross sectional dimension W of the welded portion **103** can easily be detected. Yet further, whether the welding strength is appropriate or not can easily be determined.

While certain embodiments have been described, these embodiments have been presented by way of example only, and are not intended to limit the scope of the inventions. Indeed, the novel embodiments described herein may be embodied in a variety of other forms; furthermore, various omissions, substitutions and changes in the form of the embodiments described herein may be made without departing from the spirit of the inventions. The accompanying claims and their equivalents are intended to cover such forms or modifications as would fall within the scope and spirit of the invention.

What is claimed is:

1. An ultrasonic inspection device comprising:

a vibration generating section that irradiates laser beam onto a first member to generate ultrasonic vibration;

a detecting section that detects the ultrasonic vibration propagated from the first member to a second member via a welded portion, the second member and the first member being overlapped; and

an analyzing section that analyzes the propagated ultrasonic vibration detected by the detecting section,

the analyzing section obtaining at least one of frequency and wavelength of the ultrasonic vibration detected by the detecting section upon when a displacement of the second member in a thickness direction becomes maximum, and

the analyzing section obtaining a cross sectional dimension of the welded portion from a correlated relationship of the cross sectional dimension of the welded portion obtained in advance at a position on a surface of the second member on the first member side and the at least one of the frequency and wavelength of the ultrasonic vibration.

2. The device according to claim **1**, wherein

a following equation is satisfied:

$$V/5W \leq F \leq V/W$$

where the frequency of the ultrasonic vibration detected by the detecting section upon when the displacement of the second member in the thickness direction becomes maximum is F, the cross sectional dimension of the welded portion is W, and a speed of the propagating ultrasonic vibration is V.

3. The device according to claim **1**, wherein

the vibration generating section includes a first laser beam source that emits laser beam that has high energy and is time modulated.

4. The device according to claim **3**, wherein

the first laser beam source is a pulse laser beam source.

5. The device according to claim **1**, wherein

the detecting section detects the ultrasonic vibration that is generated by the vibration generating section, and propagated to the second member from the first member via the welded portion.

6. The device according to claim **1**, wherein

the detecting section includes:

a second laser beam source that emits laser beam;

a head that irradiates the laser beam emitted from the second laser beam source onto a surface of the second member, and causes interfering light from the laser beam and reflected light from the surface of the second member to be generated; and

a converting section that detects the ultrasonic vibration from a change in intensity of the interfering light over time.

7. The device according to claim **1**, wherein

the analyzing section performs a frequency analysis of the ultrasonic vibration by fast Fourier transform.

8. The device according to claim **1**, wherein

the analyzing section determines an aptitude of welding strength based on the obtained cross sectional dimension of the welded portion and a predetermined threshold.

9. The device according to claim **8**, wherein

in a case where the obtained cross sectional dimension of the welded portion is longer than the threshold, the analyzing section determines that the welding strength is appropriate.

10. The device according to claim **1**, wherein

the welded portion is formed by at least one type of welding selected from the group consisting of plug welding, slot welding, and spot welding.

11. A method of ultrasonic inspection comprising:

generating ultrasonic vibration by irradiating laser beam onto a first member;

detecting the ultrasonic vibration propagated from the first member to a second member via a welded portion, the second member and the first member being overlapped; and

obtaining at least one of frequency and wavelength of the ultrasonic vibration detected upon when a displacement of the second member in a thickness direction becomes maximum, and obtaining a cross sectional dimension of the welded portion from a correlated relationship of the cross sectional dimension of the welded portion obtained in advance at a position on a surface of the second member on the first member side and the at least one of the frequency and wavelength of the ultrasonic vibration.

12. The method according to claim **11**, wherein

a following equation is satisfied:

$$V/5W \leq F \leq V/W$$

where the frequency of the ultrasonic vibration detected upon when the displacement of the second member in the thickness direction becomes maximum is F, the cross sectional dimension of the welded portion is W, and a speed of the propagating ultrasonic vibration is V.

13. The method according to claim **11**, wherein

in the generating of the ultrasonic vibration,

the laser beam that has high energy and is time modulated is irradiated.

14. The method according to claim **13**, wherein

the laser beam that has high energy and is time modulated is pulse laser.

15. The method according to claim **11**, wherein

in the detecting of the ultrasonic vibration,

the ultrasonic vibration that is generated by irradiating the laser beam onto the first member, and propagated to the second member from the first member via the welded portion is detected.

16. The method according to claim **11**, wherein

in the detecting of the ultrasonic vibration,

the laser beam is irradiated onto a surface of the second member, interfering light is generated from the irradiated laser beam and reflected light from the surface of the second member, and the ultrasonic vibration is detected from a change in intensity of the interfering light over time.

17. The method according to claim **11**, wherein

in the obtaining of the cross sectional dimension of the welded portion,

a frequency analysis of the ultrasonic vibration is performed by fast Fourier transform.

18. The method according to claim **11**, further comprising a process of:

determining an aptitude of welding strength based on the obtained cross sectional dimension of the welded portion and a predetermined threshold.

19. The method according to claim **18**, wherein

in the determining of the aptitude of the welding strength,

in a case where the obtained cross sectional dimension of the welded portion is longer than the threshold, it is determined that the welding strength is appropriate.

20. The method according to claim **11**, wherein

the welded portion is formed by at least one type of welding selected from the group consisting of plug welding, slot welding, and spot welding.

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